

Summary of recent studies on collimation with hollow electron beams

G. Stancari, A. Valishev, J. Annala, T. Johnson, V. Shiltsev, D. Still

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Studies summary

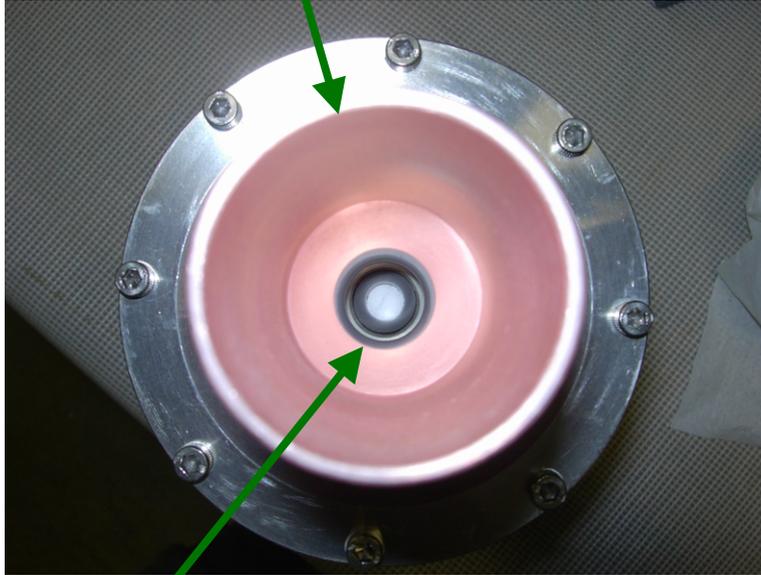
- ▶ **End of Store 8733** (May 13, 4 h):
collimator scans, diffusion vs. hole radius
- ▶ **End of Store 8749** (May 20, 5 h):
collimator scans, diffusion vs. e-beam current
- ▶ **End of Store 8763** (May 24, 2 h):
scraping with different pulsing patterns
- ▶ **Pbar-only Store 8764** (May 24, 6 h):
scraping and diffusion without collisions

The 15-mm hollow electron gun

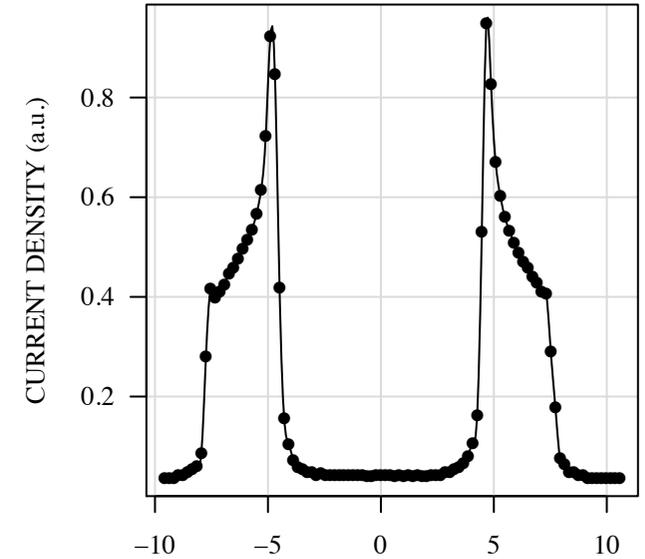
side view

Copper anode

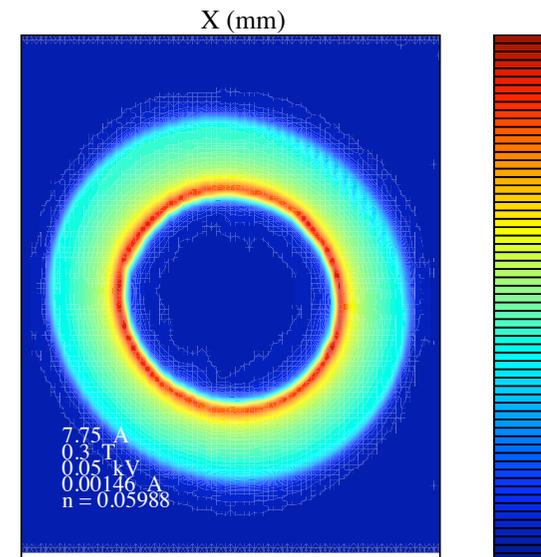
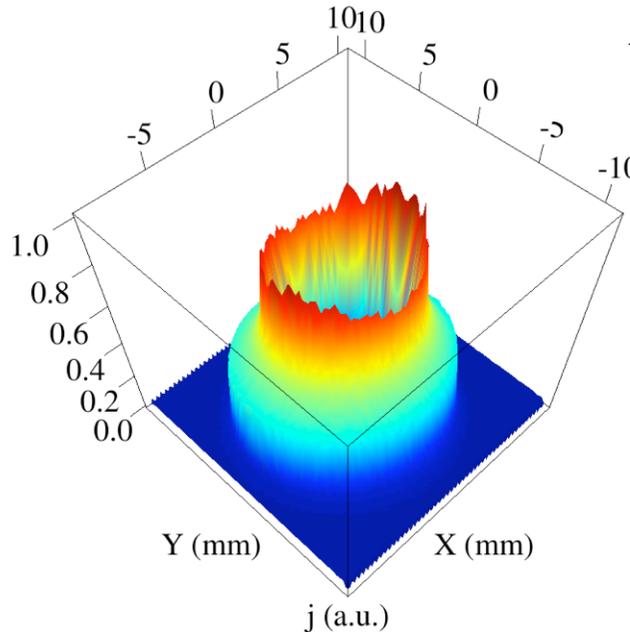
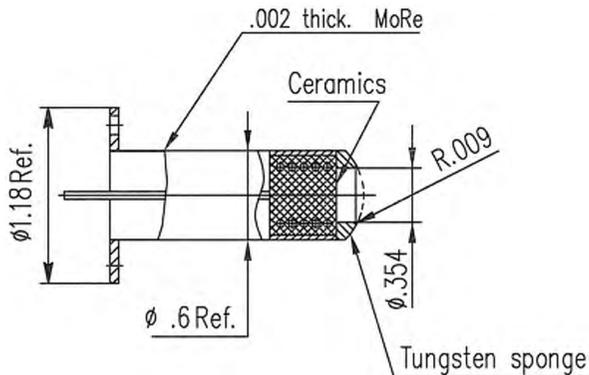
top view



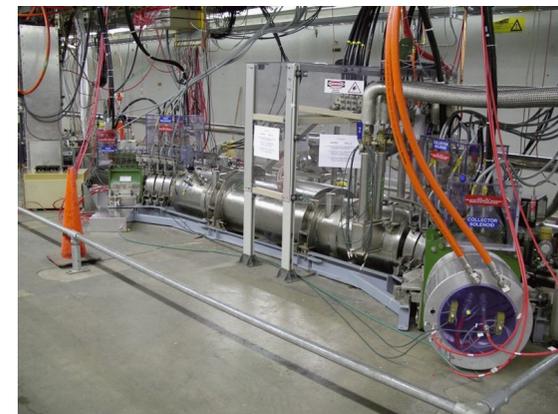
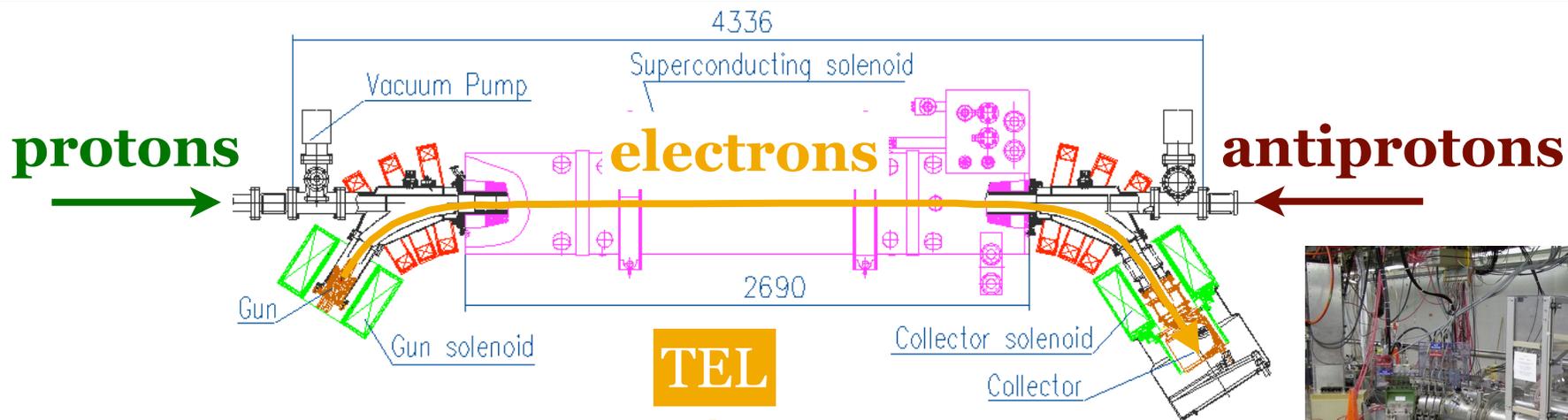
Yield: **1.1 A** at 4.8 kV
Profile measurements



Tungsten dispenser cathode
with convex surface
15-mm diameter, 9-mm hole



Layout of the beams in the Tevatron



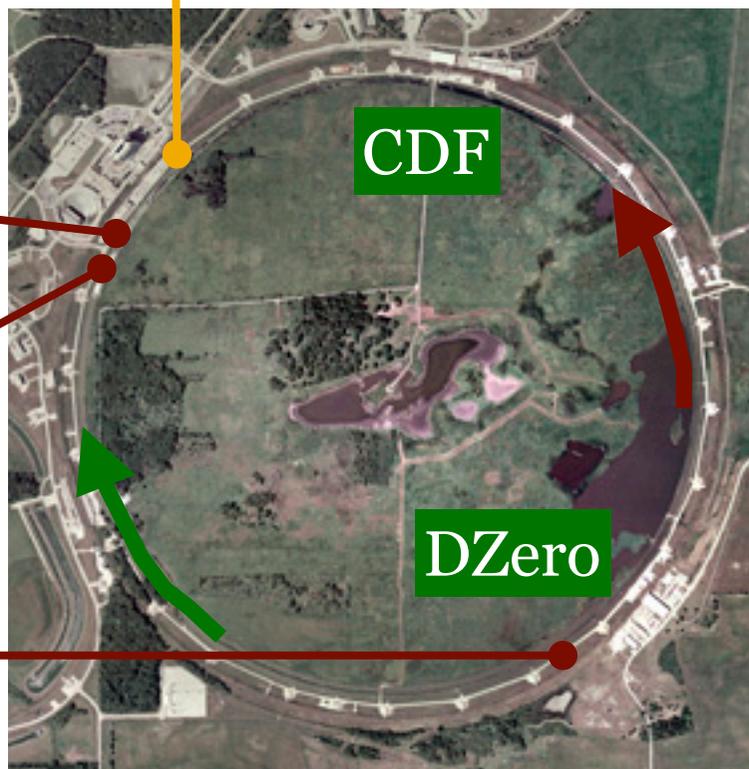
Tevatron electron lens

Antiproton collimators:

Primary (F49)

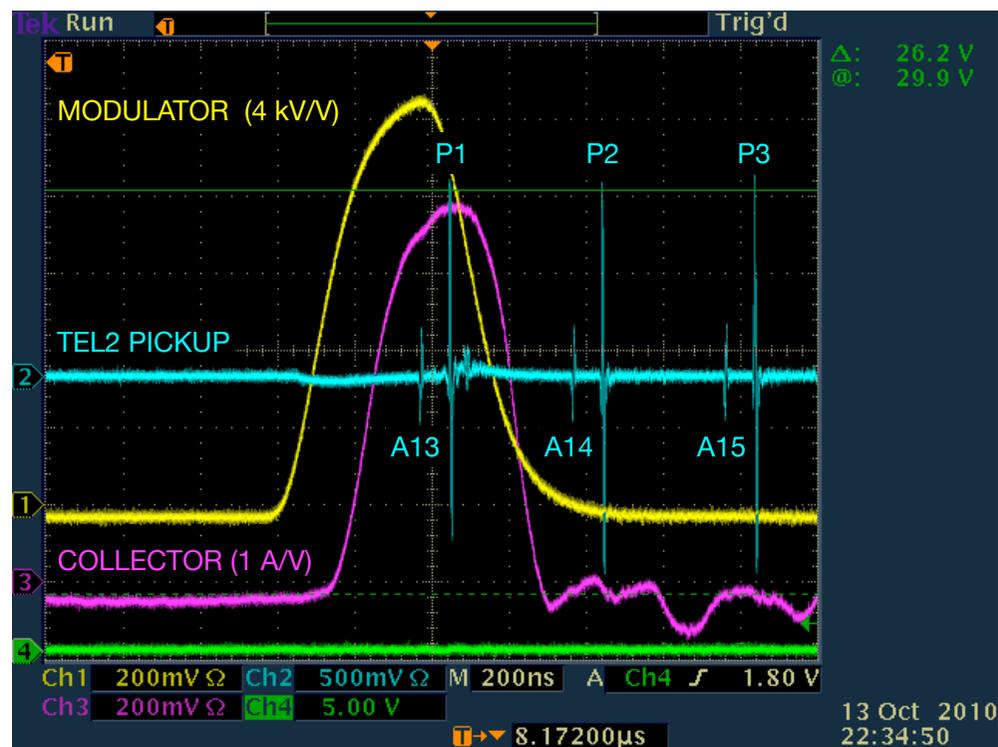
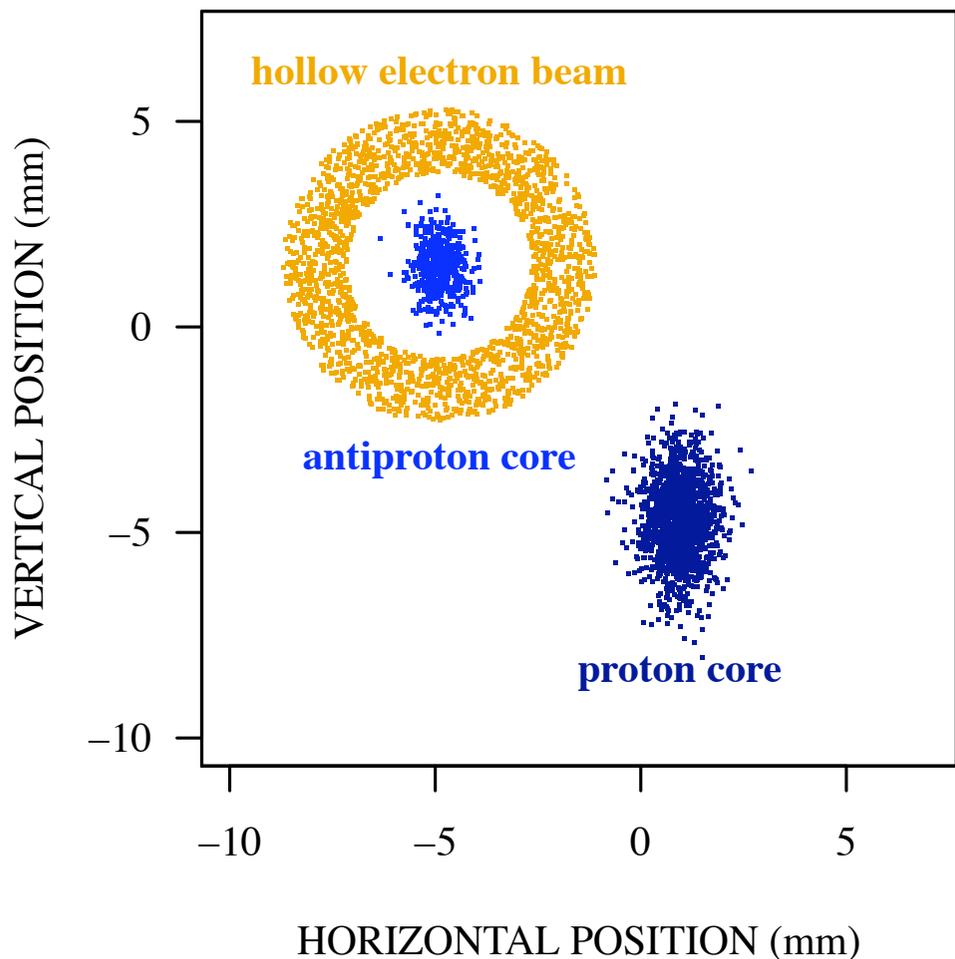
Secondary (F48)

Secondary (D17)



Layout of the beams in the Tevatron

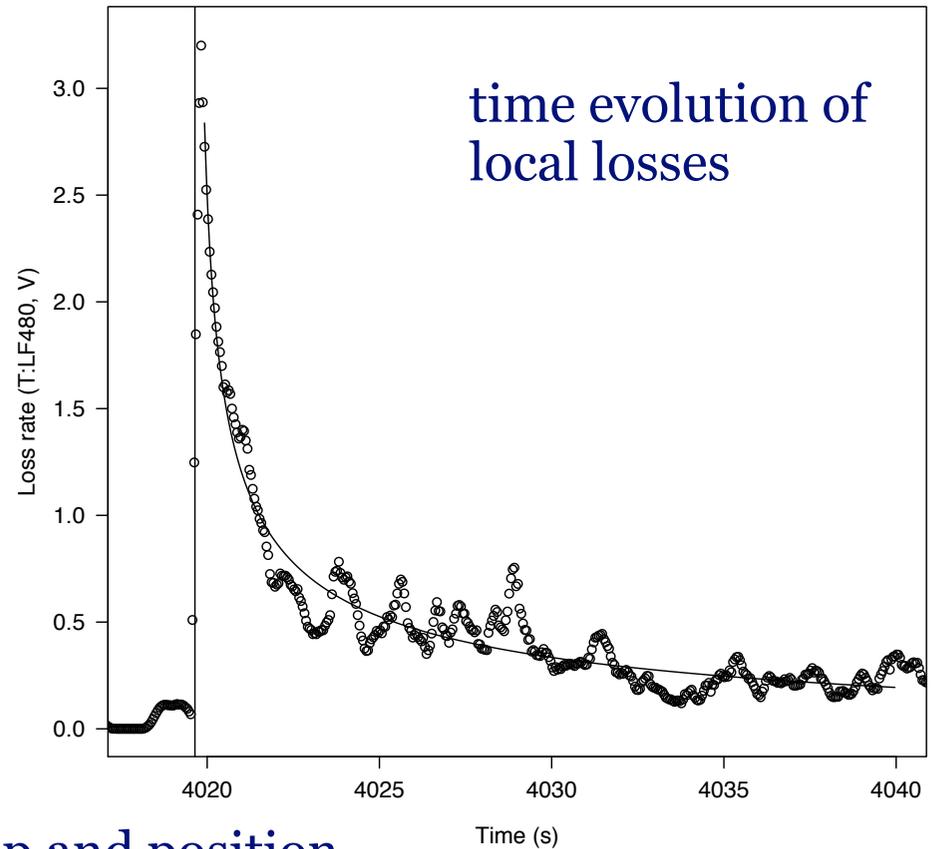
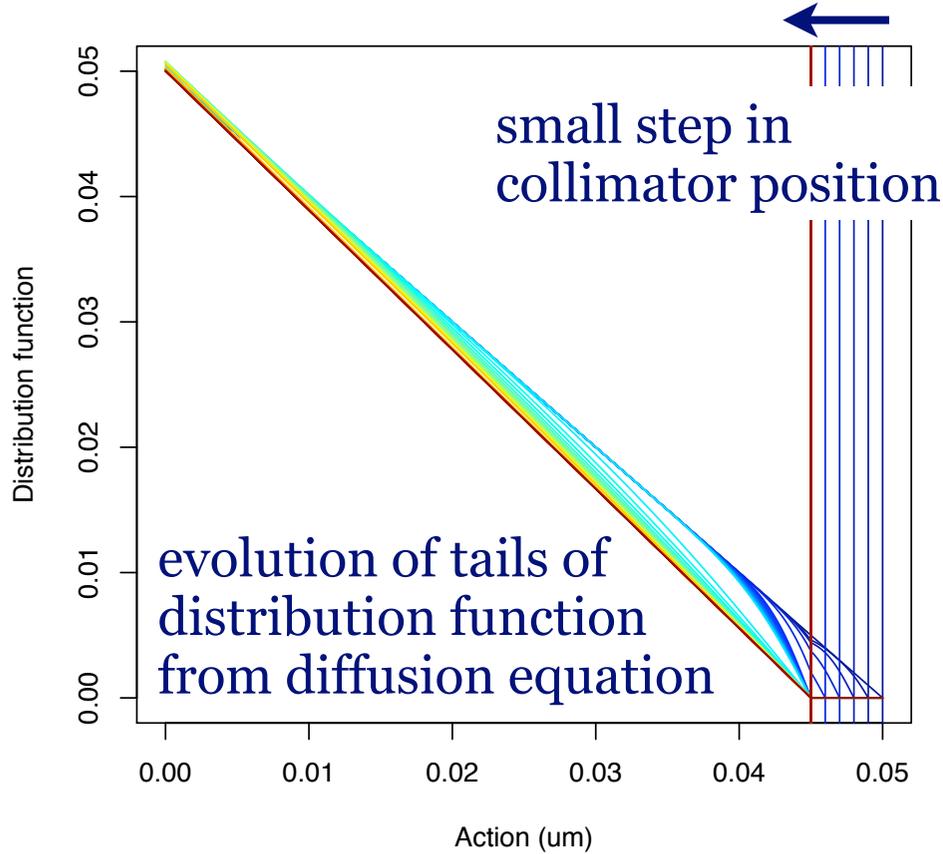
Transverse separation
is 9 mm at TEL



Pulsed electron beam
can be synchronized with
any group of bunches

Diffusion rate vs. amplitude from collimator scans

Mess and Seidel, NIM A **351**, 279 (1994)



observed loss rate

collimator step and position

background

$$L(t) = a_1 \left\{ 1 + \frac{|\Delta x_c| / x_c}{\sqrt{\pi R(t - t_0)}} \right\} + a_0$$

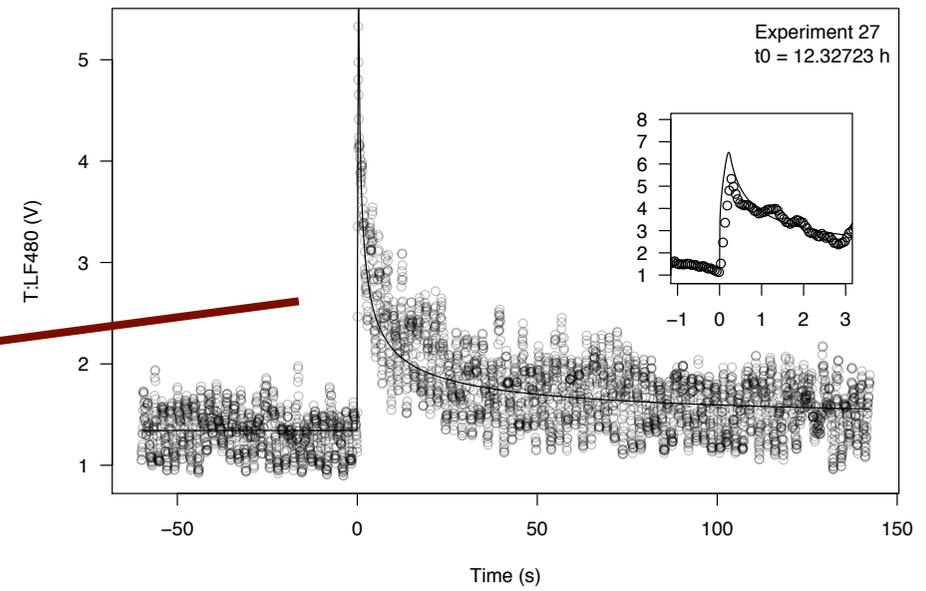
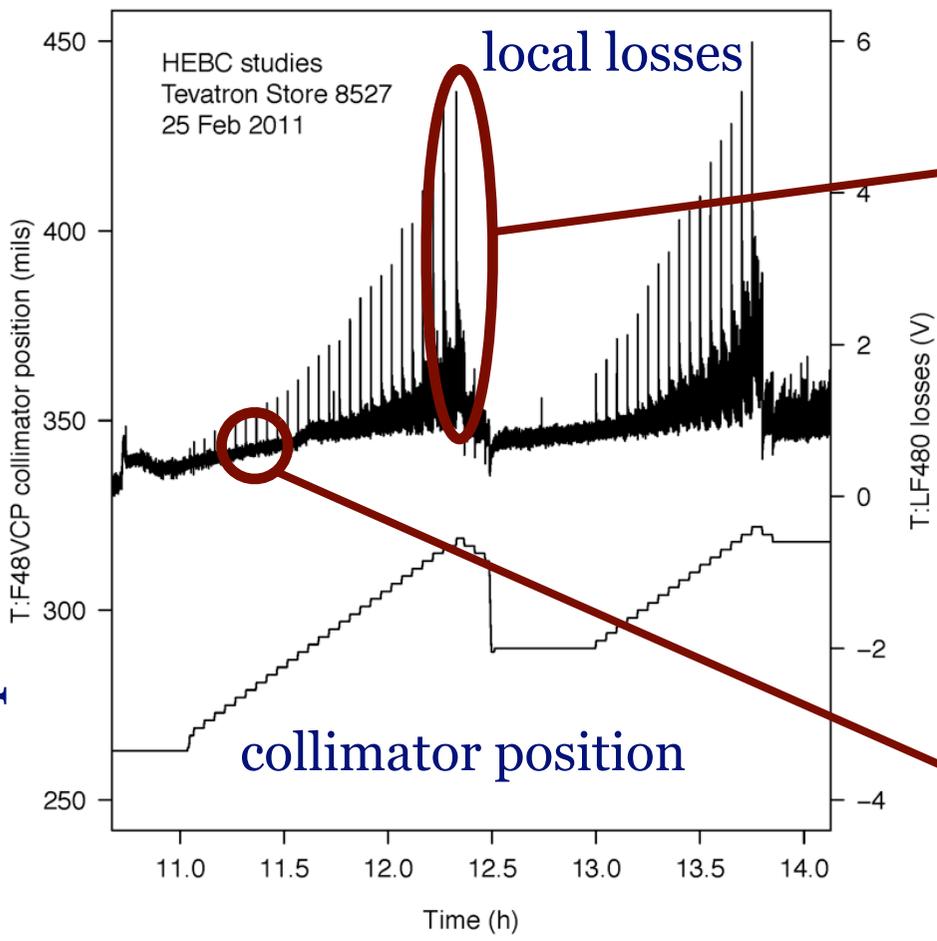
normalization (intensity, efficiency, ...)

parameter related to diffusion rate

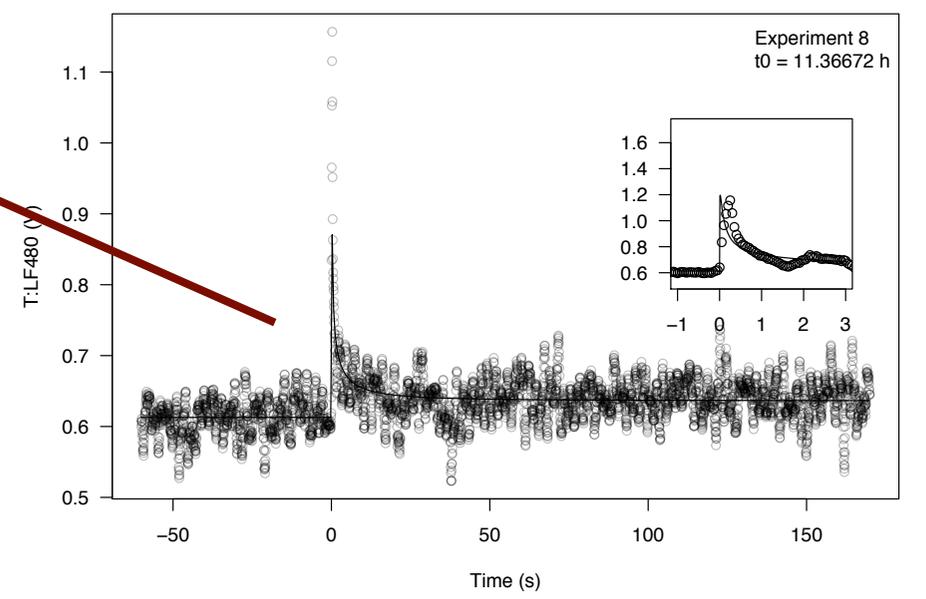
Diffusion rate vs. amplitude from collimator scans

Vertical secondary collimator scan

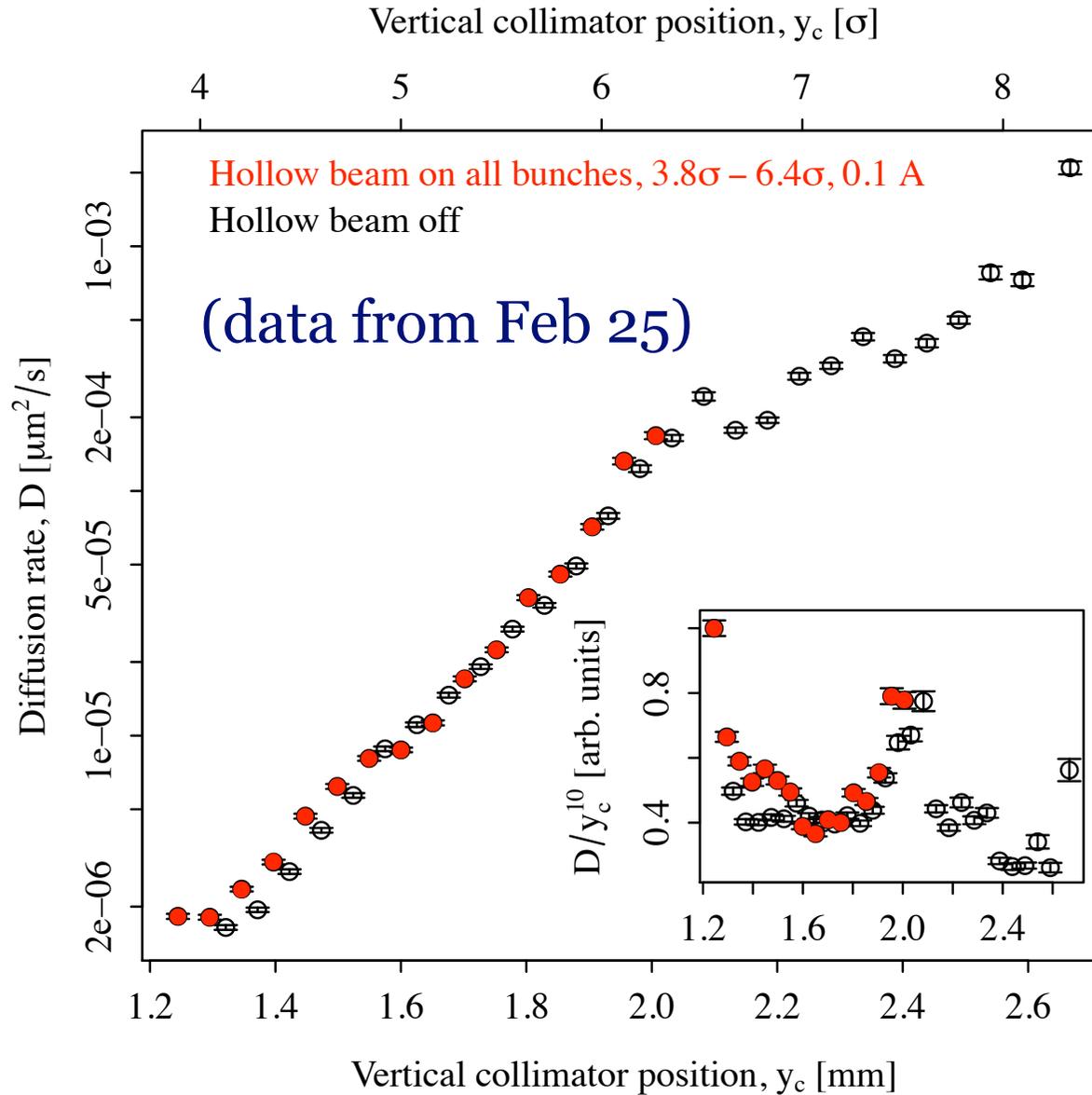
up towards beam axis



Tails repopulate faster at large amplitudes (higher diffusion rate)



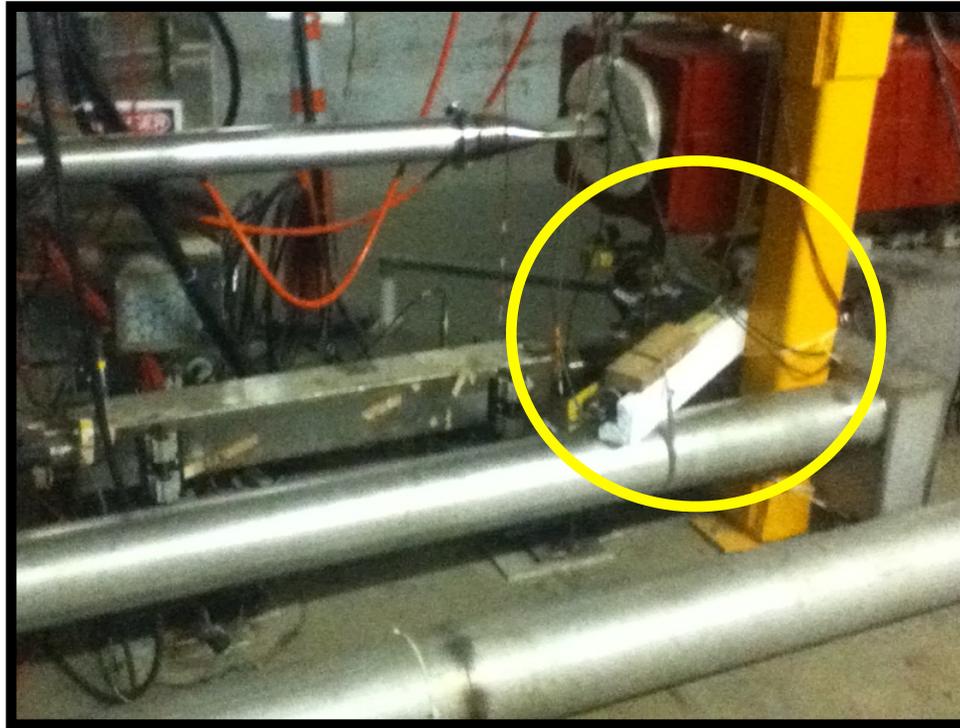
Diffusion rate vs. amplitude



- ▶ First measurement of diffusion rates in Tevatron
- ▶ Effect of e-lens at 0.1 A is small, need gated loss monitors

New gated antiproton loss monitors

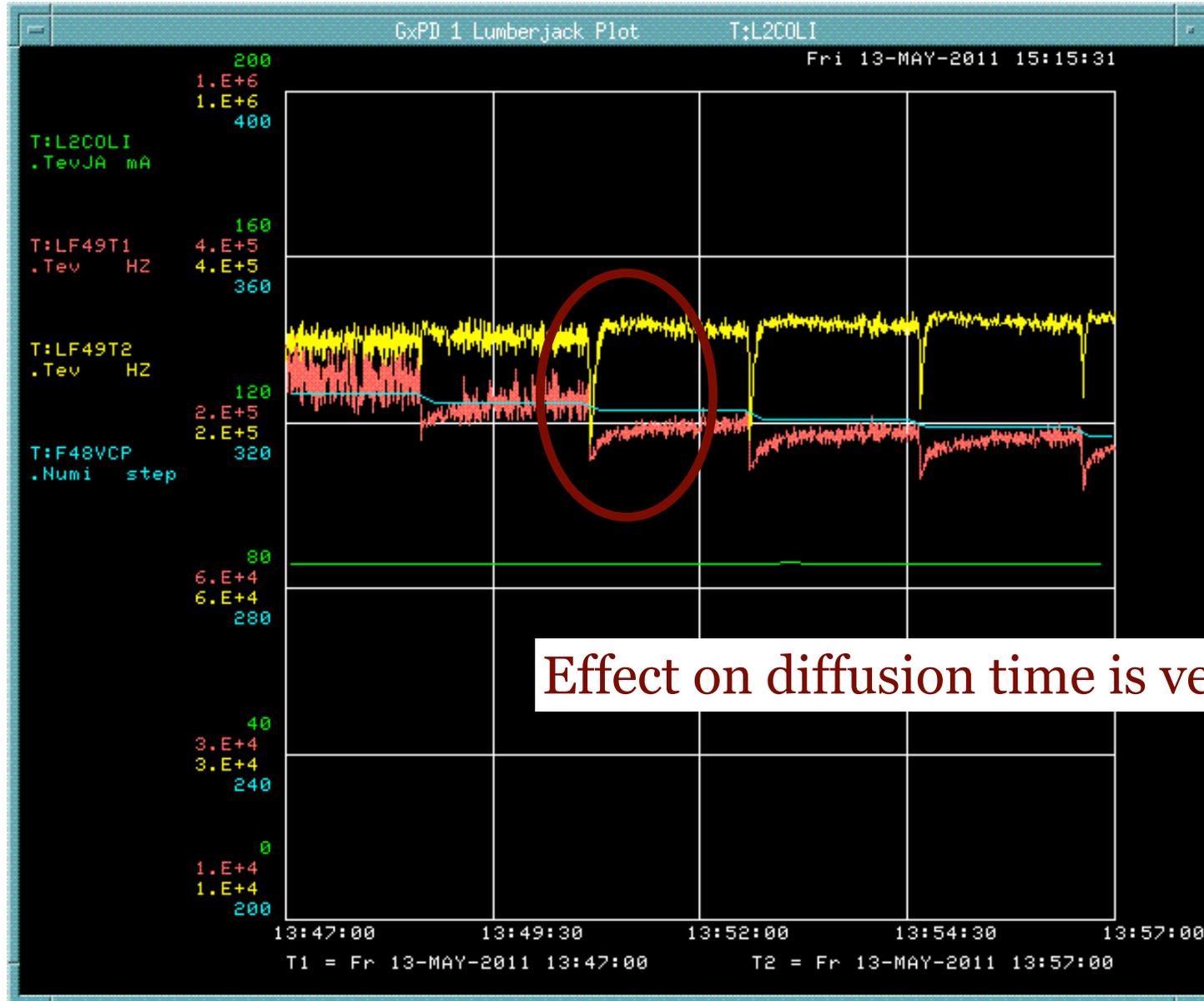
- ▶ Scintillator paddles installed near F49 antiproton absorber
- ▶ Gated to individual bunch trains
- ▶ Logged at 15 Hz: T:LF49T1, T:LF49T2, and T:LF49T3



For simultaneous measurements of **diffusion rates**, **collimation efficiency**, and **loss spikes** on affected and control bunch trains at maximum electron currents

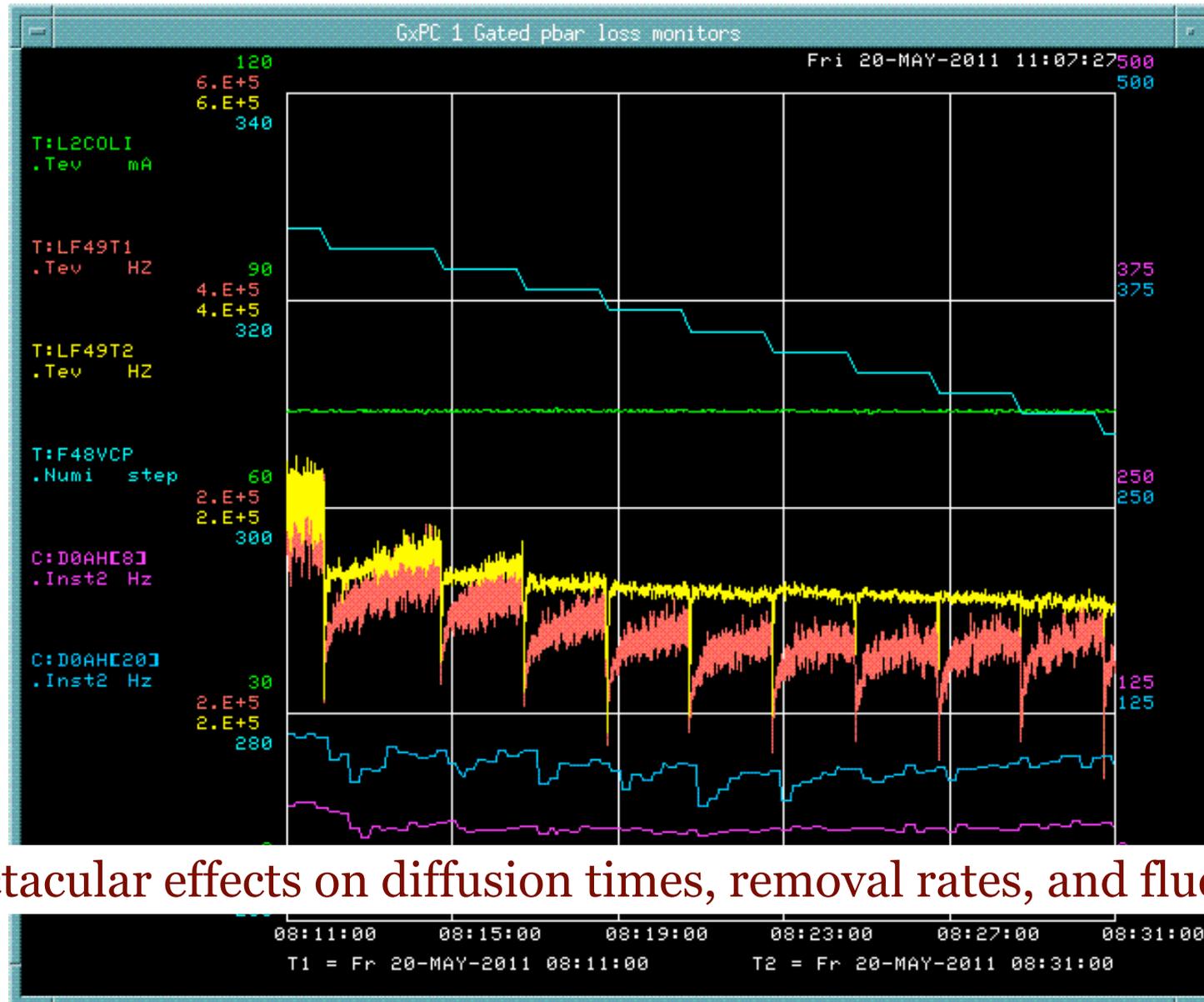
Gated losses during collimator scan (May 13)

Electrons (0.4 A) on pbar train #2, 4σ hole radius
Vertical scan of F48 collimator (others retracted)



Gated losses during collimator scan (May 20)

Electrons on half of pbar train #2 (A19-A24), 4.25σ hole radius
Vertical scan of F48 collimator (others retracted)

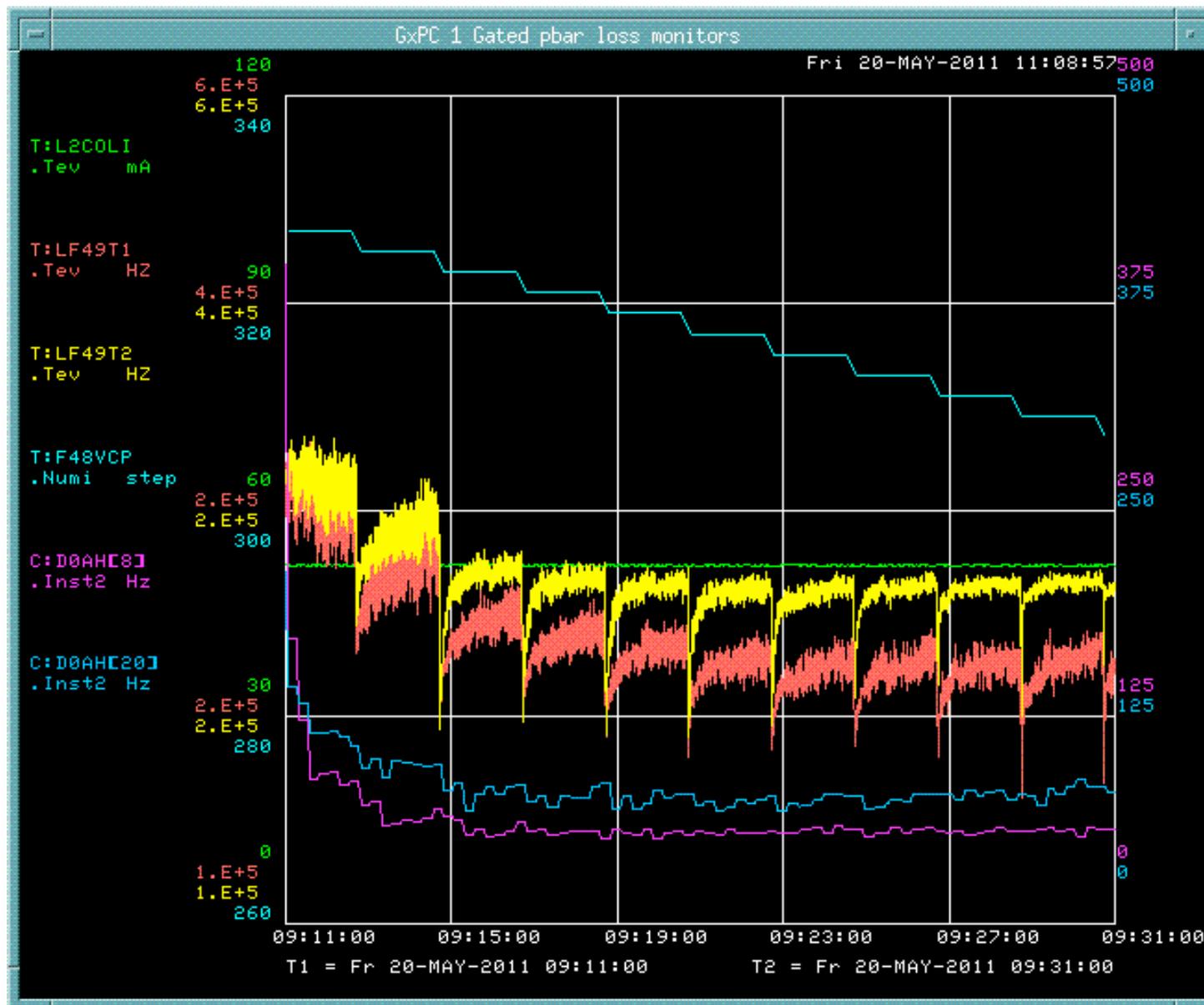


0.85 A

Quite spectacular effects on diffusion times, removal rates, and fluctuations

Gated losses during collimator scan (May 20)

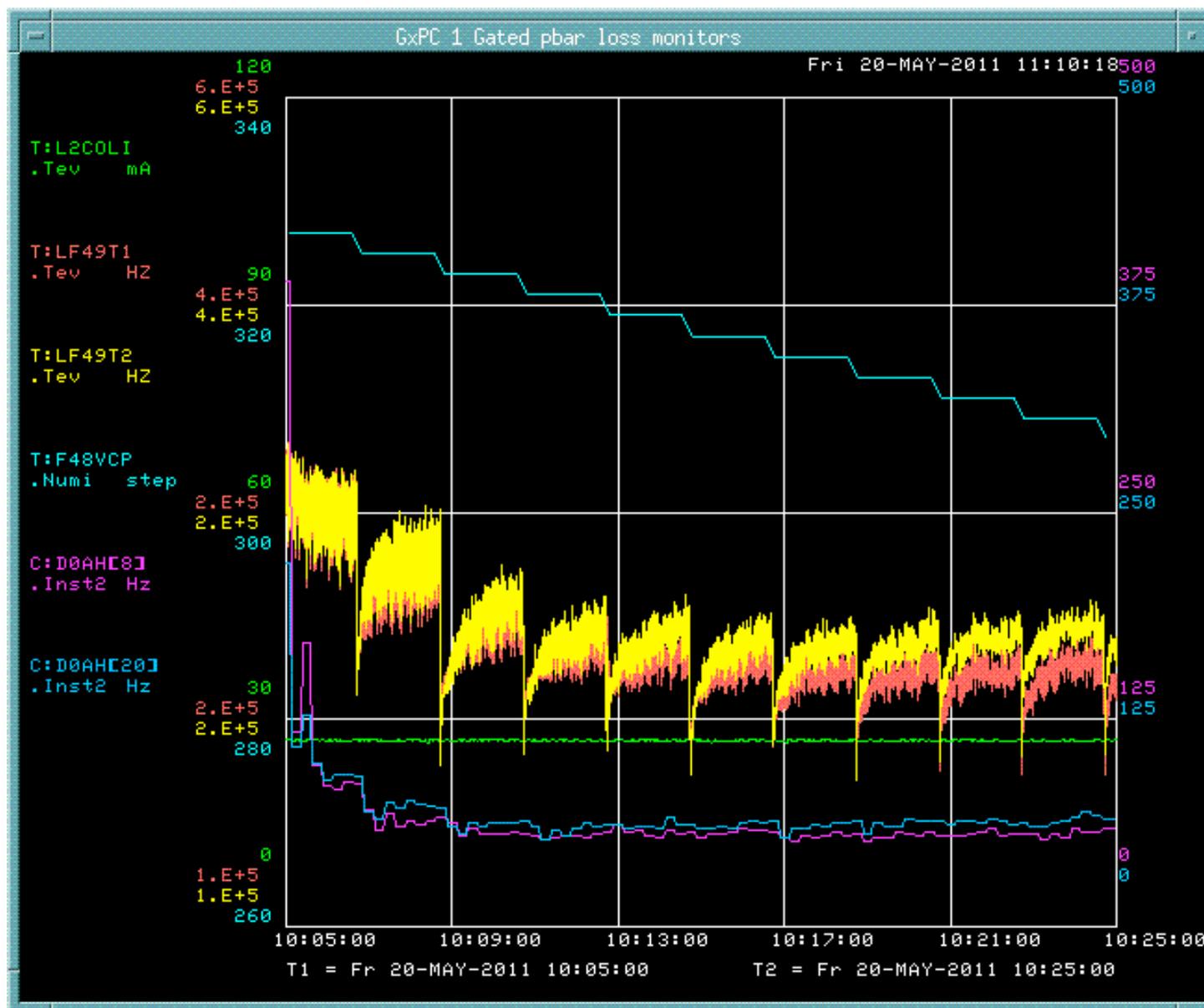
Electrons on half of pbar train #2 (A19-A24), 4.25σ hole radius
Vertical scan of F48 collimator (others retracted)



0.61 A

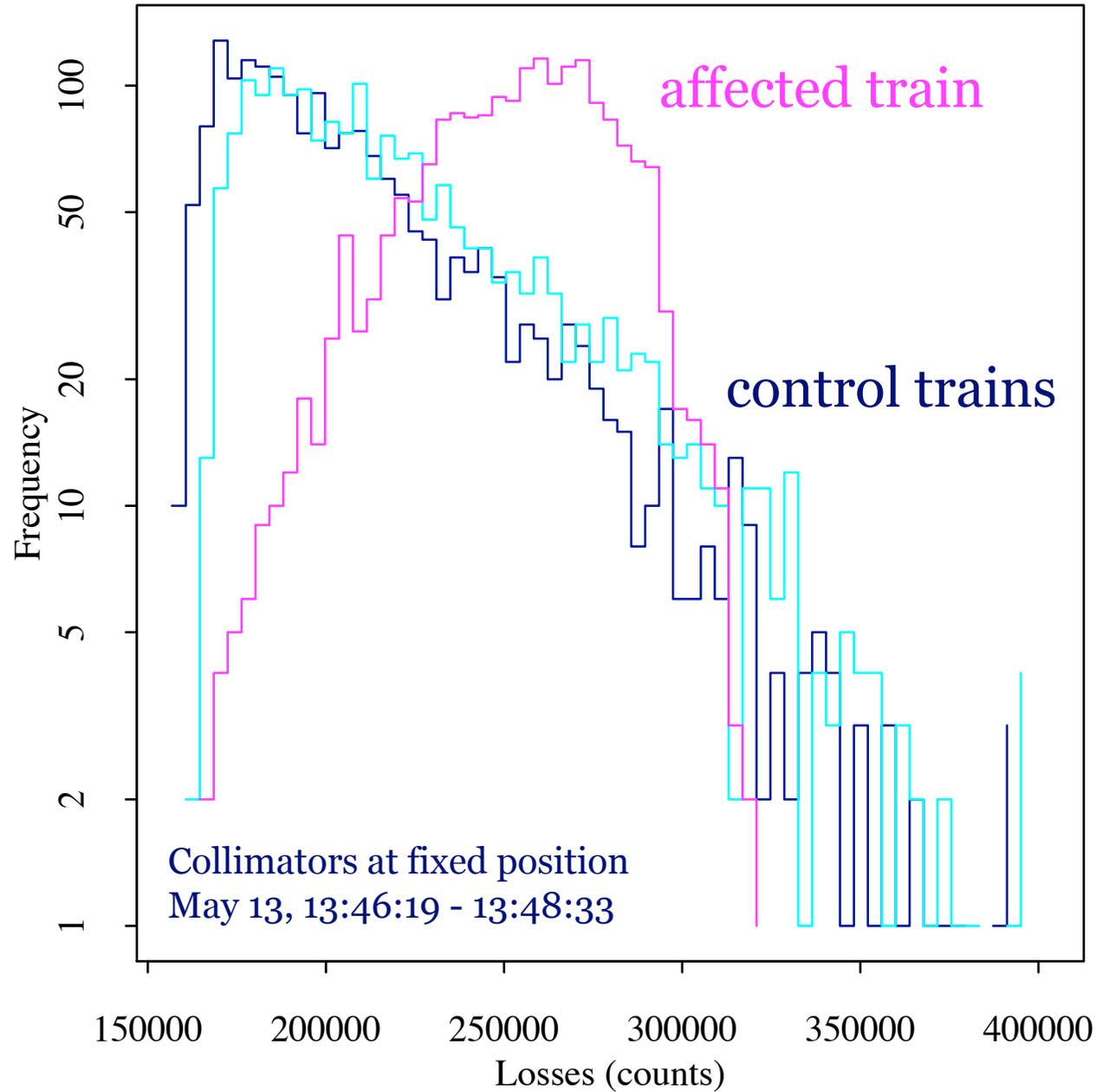
Gated losses during collimator scan (May 20)

Electrons on half of pbar train #2 (A19-A24), 4.25σ hole radius
Vertical scan of F48 collimator (others retracted)



0.32 A

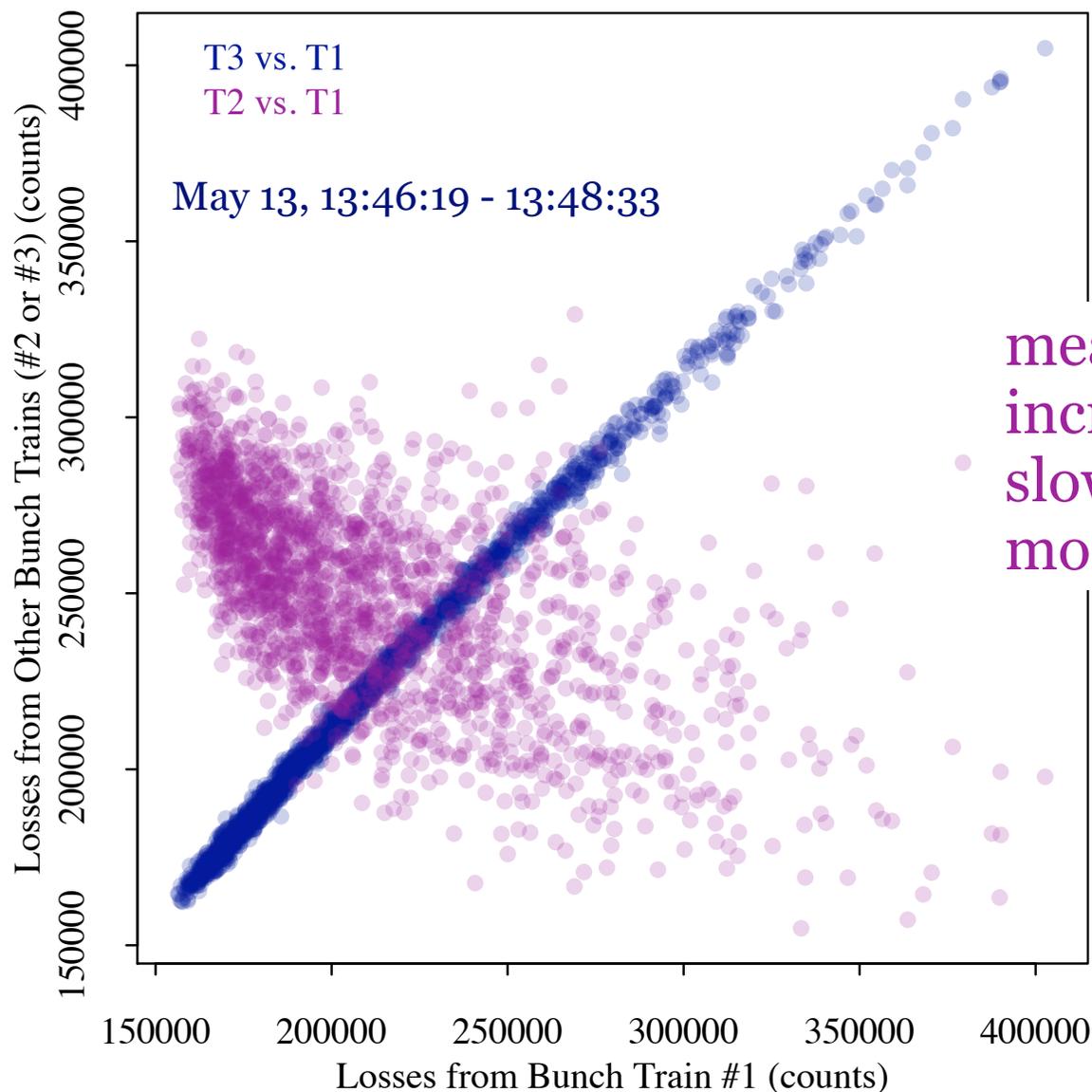
Distribution of losses



Correlation of losses - preliminary

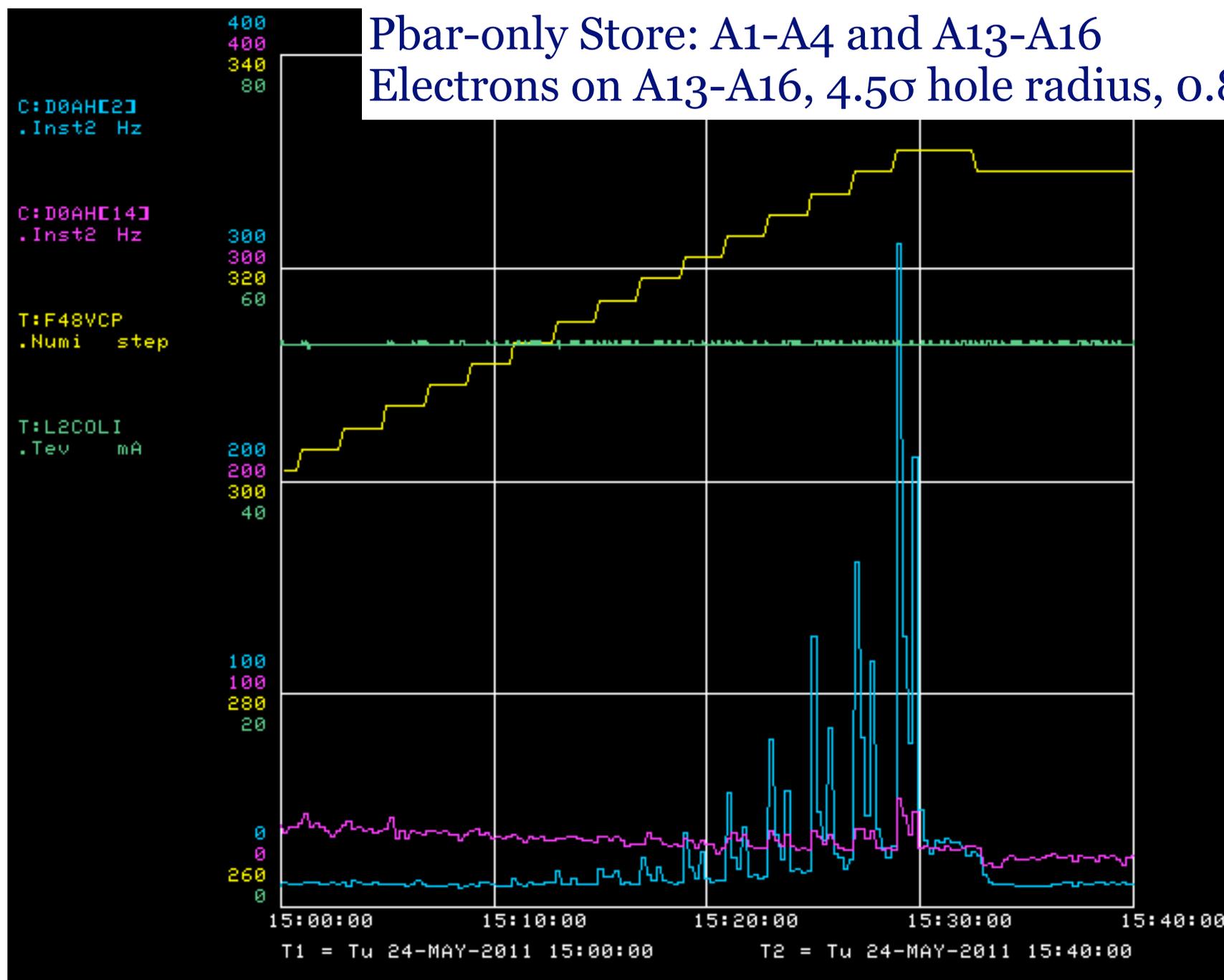
statistical fluctuations
H

beam jitter



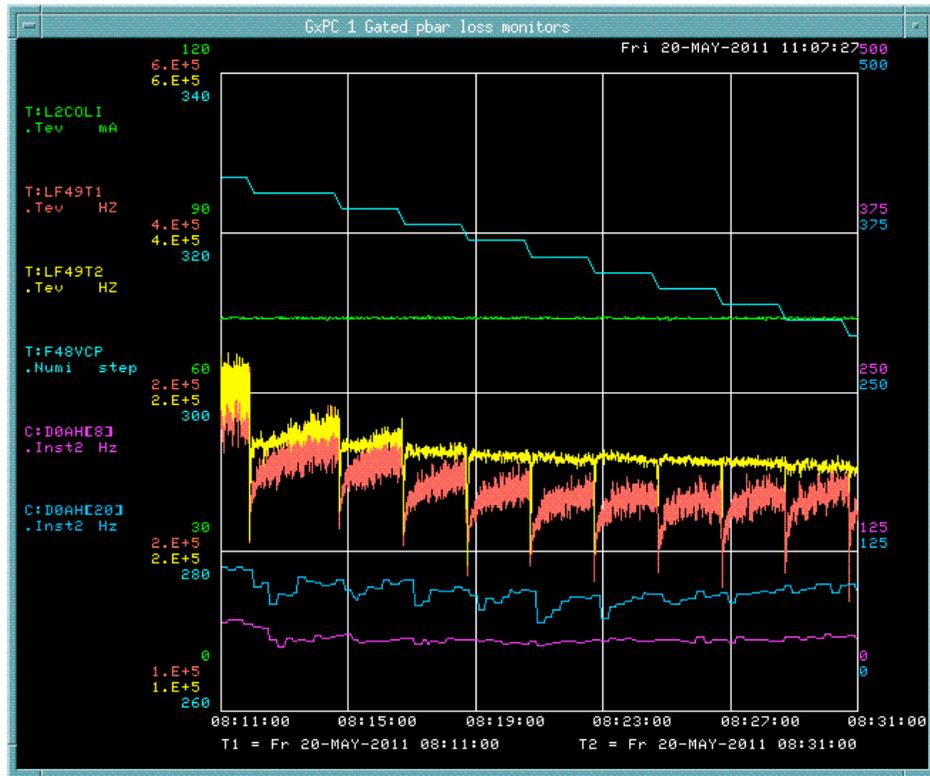
Hollow beam eliminates correlations among trains.
Interpretation: larger diffusion rate, lower tail population,
less sensitive to jitter

Reduction of DZero loss spikes when collimator is stepped in

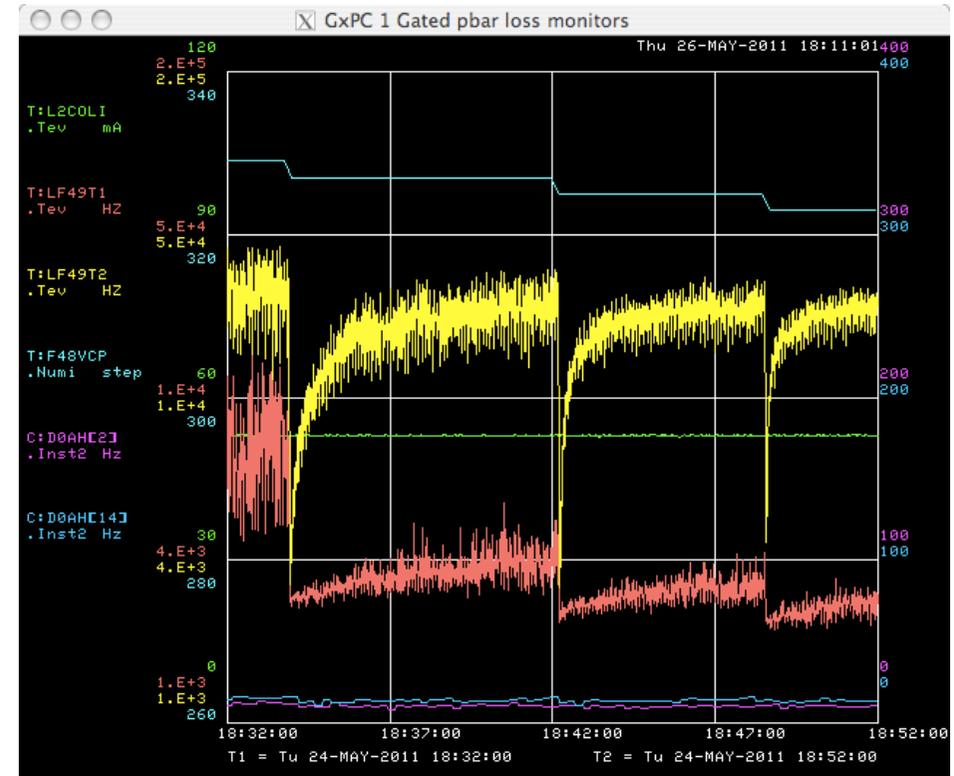


Diffusion with and without collisions

EOS 8749



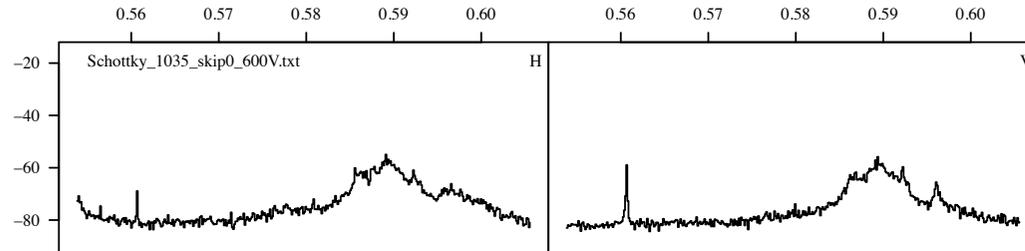
Pbar-only 8764



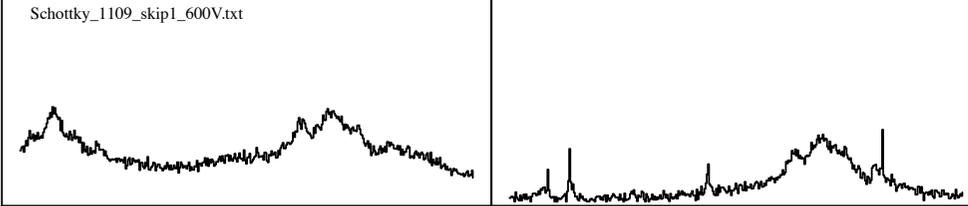
Diffusion is much faster with beam-beam (as expected)
Affected train still dominated by e-lens

Effect of pulsing pattern on Schottky spectra (May 24)

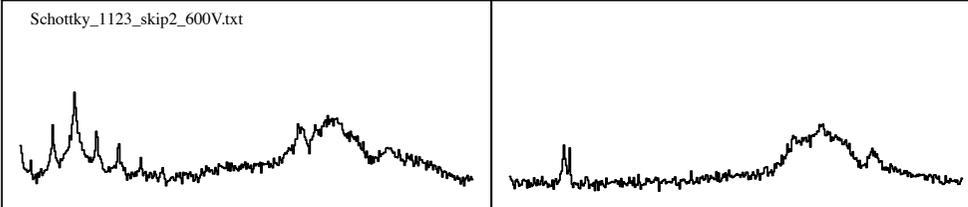
1/1 (every turn)



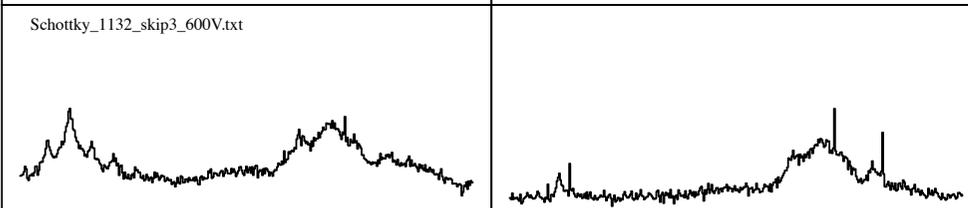
1/2 (every other turn)



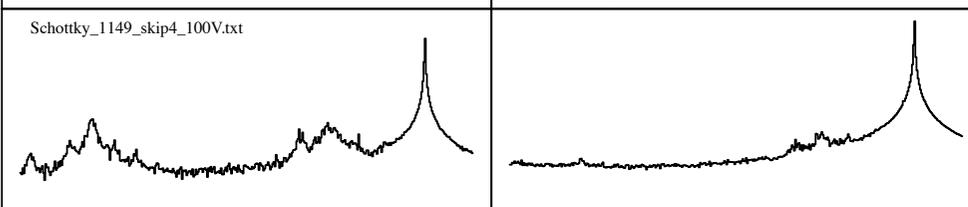
1/3 (every 3rd turn)



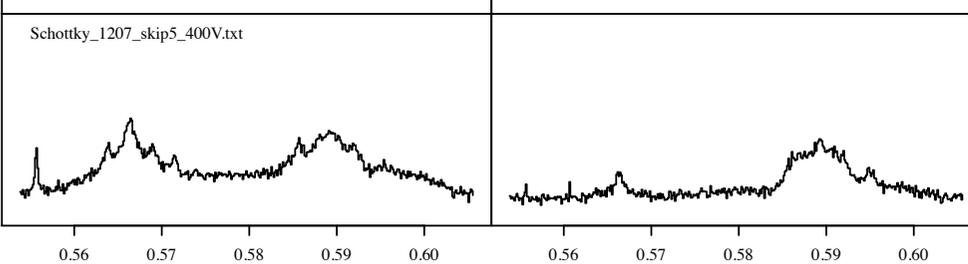
1/4 (every 4th turn)



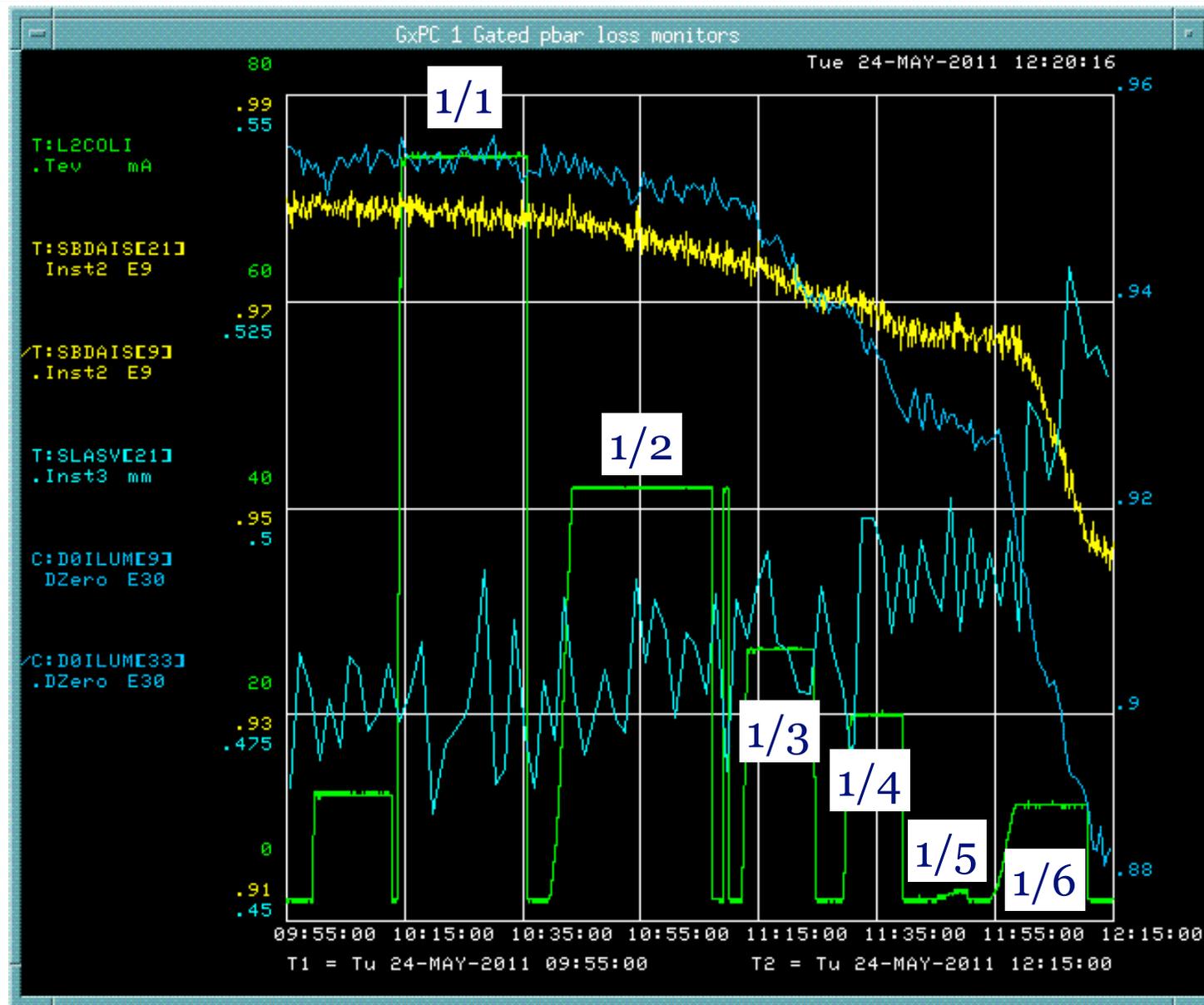
1/5 (every 5th turn)



1/6 (abort-gap cleaning mode)



Effect of pulsing pattern on scraping and emittance growth



Resonant pulsing enhances removal rate but causes emittance growth

Conclusions

- ▶ New observations of
 - ▶ diffusion rates vs. e-lens current and hole radius
 - ▶ diffusion rates with and without collisions
 - ▶ loss spikes and loss fluctuations
 - ▶ effects of resonant pulsing on scraping and emittance
 - ▶ collimation efficiencies
- ▶ Very positive CERN feedback at LARP meeting (May 16-18)
 - ▶ investigating transfer of TEL2 hardware to SPS or LHC
- ▶ Proposal for next studies, if possible:
 - ▶ calibration of collimator positions (1 h)
 - ▶ acting on a few bunches for a whole store (parasitic)
 - ▶ horizontal collimator scans for diffusion (3 h, EOS)
 - ▶ secondary collimator scans for capture efficiency (3 h, EOS)
 - ▶ scraping of protons (6 h proton-only or special collider store, $<20\pi$)
 - ▶ effect of misalignments (parasitic)